SECTION 9
TRAFFIC CONTROL DURING CONSTRUCTION

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SECTION 9
TRAFFIC CONTROL DURING CONSTRUCTION

9.1 INTRODUCTION

This Section, along with the Standard Drawings and Sample Plans, and the Manual For Traffic Control In Work Zones, have been prepared to provide Engineers with general guidelines and examples of the desirable applications for typical situations requiring lane and shoulder closures and/or lane shifts. This information may be used along with the current Manual on Uniform Traffic Control Devices (MUTCD) Part VI to prepare more detailed and site specific Traffic Control Plans that will enable a contractor to construct the project with adequate consideration of safety to motorists, pedestrians and construction workers.

Engineers should not refer to or use the Standard Drawings without proper evaluation of the specific site constraints and construction procedures required to construct the project. Traffic Control Plans should be prepared in accordance with the current Sample Plans. The Traffic Control methods established for each project should be consistent with the general provisions of this Section and should be based on good safety practices, engineering judgment, the speed and volume of traffic, the duration of the operation, the exposure to potential hazards, sight distance constraints and the physical features of the roadway including horizontal alignment, vertical alignment and the presence of interchanges and driveways. All final Maintenance and Protection of Traffic Plans must meet the approval of the Authority's appropriate Operations Department.

9.2 GENERAL

The first two sheets of the Maintenance and Protection of Traffic Plans should be as shown on the Sample Plan, as appropriately modified for individual project needs. These sheets contain a standard legend of typical traffic control devices, general traffic control notes, an escape ramp detail, a typical section for placement of construction barrier, a table showing recommended spacing of the channeling devices and a table showing recommended sight distances to the beginning of the channel tapers. The legend and general traffic control notes should be reviewed and modified to include other project specific symbols and notes as necessary for each project. The Sample Plans can also be modified to include other project specific information necessary to adequately address traffic control needs. Where required for clarification, sectional views showing the placement of traffic control devices adjacent to the traveled way and the work site should be provided. The Authority's Standard Drawings may never be revised by an Engineer.

Additional Traffic Control Plans should follow the first two (2) standard sheets. These additional plans should be included to show plan views of project specific work sites when those locations need to be represented or where design features of traffic control devices (such as the type of precast construction barrier) or temporary pavement markings need to be indicated. The scale of the Traffic Control Plans should be selected so that the optimum amount of information is shown on a

minimum number of plan sheets. The Traffic Control Plans should include a tabulation of the channelization devices needed for the project.

The Engineer shall note any recommendations that conflict with the Authority's Traffic Manual and provide justification for the Authority's appropriate Operations Department approval.

As a minimum, Traffic Control Plans should include the following items:

1. Required lane widths for each staging plan
2. Grading, drainage and utilities for temporary roadways and crossovers
3. Detours with respective detour signing
4. Temporary drainage associated with traffic staging
5. Temporary staging for drainage and other utilities
6. Temporary traffic signals and associated signal phasing design, if necessary
7. Advance warning signing for each staging plan
8. Traffic control and safety devices that are necessary for each stage of construction
9. Township and county
10. Graphic scale and north arrow
11. Allowable working hours
12. Accommodation for Pedestrian traffic (i.e. locations of temporary sidewalks)
13. Appropriate use of temporary / permanent barriers and end treatments
14. Appropriate plans and specifications to address safety concerns
15. Requirements of the State Police and/or local law enforcement

9.3 MAINTENANCE AND PROTECTION OF TRAFFIC PLANS

Maintenance and Protection of Traffic Plans should be utilized when a staging or sequence of construction needs to be specified. Notes pertaining to the various stages of construction should be included on these plans. The notes should thoroughly describe each phase of construction in the sequence to be performed.

The Legend on the Sample Plans shall be modified to show symbols for the work to be performed during each stage of construction and for work completed while construction is being performed during subsequent stages. When temporary pavement areas are required, a typical section shall be provided.

During all phases of paving, staging should provide for no exposure to drop-offs and uneven pavement adjacent to and between travel lanes.

To improve the riding quality of new bituminous concrete pavements, wherever possible, the top layer of the bituminous concrete surface course should be paved as a single stage of construction for the full width of the traveled way, shoulder and auxiliary lanes. Therefore, development of the Traffic Control Plans for projects involving paving operations should specify a Construction Sequence in which work progresses up to the bottom of the top layer of the surface course. The top layer shall be shown as the final paving stage.

Engineers shall not have traffic riding on Unbound Paving Materials. The appropriate striping shall be in place on all open roadways.

9.4 TRAFFIC IMPACT REPORT

As part of the development of the Traffic Control Plans, the Engineer shall conduct an analysis of construction related impacts. For construction on roadways other than the New Jersey Turnpike or Garden State Parkway, the findings should be presented in a detailed Traffic Impact Report that addresses the following items:

1. The existing traffic volumes and capacity data on the roads likely to be substantially impacted.
2. The projected traffic data at the start of construction including nearby highway construction projects as well as private construction projects.
3. The potential impacts of the construction on traffic through the project and along any detours.
4. The potential impacts to existing adjacent property, including shopping centers and sports facilities.
5. Recommendations for traffic impact mitigation, e.g., nighttime work, restricted hours of operation, number of lanes available for traffic, width of lanes, requirement for alternating traffic, staging requirements, public information program, and transportation demand management strategies such as park and rides, shuttle buses, flextime, etc.

The Authority's appropriate Operations Department shall be consulted during the development of the Traffic Impact Report through the Authority's Project Manager. The Authority's appropriate Operations Department will provide the Engineer with the permissible New Jersey Turnpike and Garden State Parkway lane and roadway closing hours for a project.

9.5 DEVELOPMENT OF TRAFFIC CONTROL PLAN DESIGN PARAMETERS

The Authority recognizes the need to effectively and efficiently manage traffic through construction projects in order to reduce congestion, maintain high standards of safety for workers, pedestrians and motorists, and minimize impacts to the local community both business and residential.

On the New Jersey Turnpike and Garden State Parkway, congestion is mitigated through the use of their lane reduction tables. Any lane or roadway closings outside the allowable times will not be considered, unless the Engineer proposes a method to mitigate the speed differential risk, including but not limited to a traffic queue warning system. The Engineer shall also evaluate ramp construction to determine and mitigate any truck overturn risk.

To this end, the scoping, design, scheduling and construction of projects should be accomplished in a manner that will provide standards of safety for workers and the traveling public, minimize congestion and community impacts by maintaining levels of service close to preconstruction levels and provide the contractor with adequate access to the roadway to complete the work efficiently, while meeting the quality requirements of the contract.

In order to achieve these objectives, an Engineer shall utilize the Authority's Road User Cost Manual and the appropriate Traffic Manual to evaluate potential alternatives, in terms of cost to the traveling public, as directed by the Authority's Project Manager. All projects should be designed to minimize road user cost impacts. This may be accomplished through a variety of means including, but not limited to, reduced daytime construction hours, nighttime operations, detours, diversionary roads, crossovers, the use of shoulders as travel lanes, temporary roads and bridges, alternating traffic patterns, non-traditional methods of completing the work, and using faster setting materials. The incorporation of design elements to ease traffic impacts during future construction should also be considered. These could include wider lanes, shoulders or right of way, full depth shoulders, removable sidewalks on bridges, and other alternatives.

The basic safety principles governing the design of permanent roadways and roadsides should also govern the design of construction, maintenance and utility work sites. The goal shall be to safely route traffic through these areas with geometrics and traffic control devices, as nearly as possible, comparable to those for normal highway situations, with the design speed that is specified by the Authority's appropriate Operations Department. The following items should be considered in determining the overall approach to project specific traffic control:

1. Regarding hours of operation or lane restrictions, consideration should be given to the location of the project and calendar of events. Unless there are valid reasons to the contrary, travel lanes should not be reduced in number or width, nor work be permitted to interfere with traffic, on weekends, holidays (including the PM peak the day before and the AM peak the day after) and days of special events of major traffic generators near the project site, such as the Meadowlands Complex, Garden State Arts Center, shore areas during the summer, etc.

2. Through the Authority's Project Manager, discuss the project with the Authority's appropriate Operations Department to determine the number of lanes which can be closed during the day, during the night, or on weekends. Incorporate seasonal variations into the analysis. Through the Authority's Project Manager, the Engineer shall contact the Authority's appropriate Operations Department, which has jurisdiction and ask what lane or road closings they will allow and discuss independent findings with them. With concurrence from the responsible Operations Department, define the allowable lane closing periods.

3. Provide minimum lane widths of 11 feet for all lane shifts and diversionary roads, except where existing lane widths are 10 feet.

4. Determine if detour routes are available. If potential detour routes exist, determine if their use would enhance the constructability of the project.

5. Determine if shoulders or temporary pavements can be used by traffic. Shoulders may require reconstruction prior to placing traffic on them. Short temporary roads may provide access to other existing roads making a detour possible.

6. Determine if guide rail has to be removed or relocated. If removal of guide rail reveals a blunt end then temporary impact attenuators should be provided.

7. Determine if temporary signals are required.

8. Determine if there are any reasons why a construction project should be substantially accelerated when under construction. If there are reasons for an accelerated construction process, discuss proposed methods of implementation with the Authority's project manager to determine the details of the acceleration (i.e. number of crews required, hours of work).

9. Using the Roadway Plans, determine the duration of the various construction operations required to build the project. Using this information, determine if lane closings can be set up and broken down over one work shift (8 hours±), over the weekend (Friday night to Monday morning), or must lane closings be maintained for longer continuous durations. Lane closings beyond the times specified in the Lane Reduction Tables are not permitted without the prior approval of the Authority's appropriate Operations Department. All of the above may apply. For New Jersey Turnpike and Garden State Parkway projects, the permissible lane closing hours are specified in the appropriate Traffic Control Manual.

10. Determine whether or not Movable Construction Barrier should be used. Refer to Subsection 9.9.

11. Review the guidelines for nighttime construction described in Subsection 9.10.

12. Review the time allowed for the staging of paving operations. Provide the appropriate amount of time for sufficient curing, deck patching, cooling asphalt pavement, placement of pavement markers and striping as necessary.

9.6 TEMPORARY TRAFFIC STRIPES AND TRAFFIC MARKINGS

The Authority's policy on temporary traffic stripes and traffic markings is as follows:

1. Traffic paint (latex or alkyd) shall be used when traffic stripes or traffic markings are required on intermediate pavement layers that need to be opened to traffic due to stage construction. The traffic stripes shall be calculated in linear feet for each 6 inch width of actual stripe (gaps are not counted) under the item TEMPORARY PAVEMENT STRIPING. Diagonal gore lines, crosswalks, and stop lines shall be calculated in linear feet for each 6 inch width of actual stripe under the item TEMPORARY PAVEMENT STRIPING (Linear Foot). Words, arrows and other pavement symbols shall be calculated in square feet under the supplementary item TEMPORARY PAVEMENT MARKINGS, SYMBOLS (Square Foot). Where lane shifts are necessary on the intermediate layers or on existing pavements not being repaved, and temporary striping will remain in place less than three (3) months, removable pavement marking tape or temporary pavement markers shall be specified and calculated accordingly. The placement of temporary pavement markers shall be in accordance with the Sample Plans.

2. Long life traffic stripes or traffic markings may be considered for stage construction, detours, and diversionary roads on those occasions when it can be justified based on cost considerations, site conditions, or length of time when the stripes or markings will be in place.

9.7 LANE AND ROADWAY CLOSURES

9.7.1 Lane Closures

The Engineer should modify the Sample Plans to provide a table showing specific restrictions placed on travel lanes, durations of closures and hours when work may be performed, including holidays and weekends. The permissible lane and roadway closing times for the Turnpike and Parkway will be specified by the Operations Department. The closures and lane restrictions on other roadways shall be evaluated in the Traffic Impact Report, refer to Subsection 9.4. The following table is provided as an example of the form of presentation of this information:

Roadway Route Designation and Direction	Type of Closure	Monday thru Thursday	Friday	Saturday	Sunday
	No Closure				
	One Lane Closure				
	Two Lane Closures				
	Full Closures (indicate duration and type of operation)				

Mobile lane closures shall only be permitted for the types of work specified in the Standard Drawings.

9.7.2 Traffic Slowdowns

Total roadway closures (i.e. all lanes, single direction or two directions) required for the erection of overhead sign structures, cantilevered sign structures or bridge steel shall be performed in accordance with the following:

1. The use of roadway closures shall be specifically addressed in the Traffic Impact Report, refer to Subsection 9.4, and shall be considered only after detours have been determined to be unavailable or unfeasible.

2. Slowdowns shall be approved by the Authority's appropriate Operations Department.

3. Slowdowns shall be performed during non-peak hours and with prior approval of the Resident Engineer concerning the timing and method of operation.

4. Nighttime construction for the erection of the various structure types is preferred, refer to Subsection 9.10.

5. The erection of overhead and cantilever sign support structures shall be done only when overhead electric lines, if there are any within 100 feet, have been de-energized.

6. Slowdowns shall be initiated with a slow down of traffic approximately 1/2 mile in advance of the work area.

7. Slowdowns, whether single direction or two directions, shall be limited to 5 minute intervals. At the end of each 5-minute interval, the work must stop, and traffic allowed to pass. After traffic has cleared, the roadway may again be closed for another maximum 5 minute interval, repeating the same procedure, and work may resume. Continue this procedure until all work over the roadway is complete. Slowdowns in excess of 5 minutes may occur when no other option exists, and they require special coordination with the appropriate Authority Operations Department and the State Police.

9.7.3 Roadway Closures

The use of roadway closures for specific work shall be approved by the Authority's appropriate Operations Department during the design phase of a project. The actual date and time of a roadway closure will not be determined during design.

9.7.4 Center/Interior Lane Closures

Existing roadway facilities with three or more lanes in each direction often require the closure of interior lanes to perform construction activities. The Standard Drawings provide the methods for maintaining traffic during construction in an interior lane. In addition to the Standard Drawings, specific project/site conditions should be evaluated when determining the appropriate details to use. Generally, center lane closings on the New Jersey Turnpike and Garden State Parkway are to be avoided to the greatest extent possible.

9.7.5 Alternate Traffic Routes on Projects Involving Local Road Construction

9.7.5.1 General

Alternate traffic routes located where high approach speeds are anticipated should be of a high-type design. Transition lengths, curve radii, superelevation and other design features should be consistent with the design speed of traffic that will be entering the alternate traffic route.

9.7.5.2 Diversionary Roads

If a temporary roadway is to be constructed on Authority right of way or easement as part of the contract to carry traffic around a construction site it should be referred to as a "diversionary road" and not an official detour. It is desirable that diversionary roads used for construction zone traffic control have the same design speed and cross section as the existing roadway. The minimum design speed of the diversionary road shall be 20 mph less than the design speed of the existing roadway.

9.7.5.3 Detours

The Authority is required to obtain County or Municipal permission to close, or otherwise impact roads or streets because of construction. It is the Authority's policy to meet with the proper authorities and to obtain their permission and cooperation beforehand and obtain approval during Phase “B”.

An official detour exists whenever, as a result of roadway construction, existing roadways are to be closed temporarily and it becomes necessary to reroute Authority, State, Municipal or County Road traffic over other existing streets or roads to maintain the normal flow of pedestrian and vehicular traffic.

The roads or streets to be used for the detour shall be examined to make sure they are acceptable from the standpoint of condition, safety, necessary signing, lighting and repair. A detour map, together with recommendations for signing, repair, limitations, if any, should be prepared and submitted as part of the project design. Approval of the project makes the detour "legal". By State Statute, the Authority is required to obtain prior permission to improve Municipal streets.

The Authority is responsible for all of these arrangements. Should situations of this type exist which are not being handled as described, the Authority's project manager should immediately be contacted so that proper action can be taken. Provisions shall be made for videotaping the detour road(s) before and after construction.

9.7.5.4 Haul Roads

A Contractor may use the local roads to transport materials for the construction project. Haul roads are not considered detours. Municipalities may not levy charges against the haul vehicles if they are licensed to travel on any road in the State, but they can place limitations if weight restrictions exist. The Engineer shall investigate for such restrictions during the course of the design, as long as they meet all existing regulations.

9.7.6 Traffic Shifts

9.7.6.1 Clear Zone

In the absence of protective roadside devices for lane shifts or any traffic pattern that alters the existing clear zone, the clear zone shall be maintained and conform to the requirements set forth in Section 3 (Guide Rail / Median Barrier / Attenuator Design).

9.7.6.2 Shoulder Condition Evaluation

Existing shoulder pavement shall be evaluated to determine if it is suitable for use by traffic. Above average heavy vehicle percentages shall be used for any design calculations. Pavement cores may be required to determine asphalt properties for the evaluation. All

drainage systems shall be inspected and repairs/retrofits identified as required. Cross-slope of shoulders shall be determined and modifications to the cross slope shall be recommended as required.

9.7.6.3 Temporary Shoulders

Temporary shoulders shall be constructed within the limits of traffic shifts when the shoulder width is reduced to less than 2'-0" at locations where roadside protective devices are not present.

9.7.6.4 Rumble Strips

Longitudinal rumble strips shall be reconstructed but need not be present prior to returning traffic to the original alignment.

9.8 PRECAST CONCRETE CONSTRUCTION BARRIER

9.8.1 Introduction

In general, Precast Concrete Construction Barrier should be installed only if it is clear that the barrier offers the least hazard potential. Elimination of the warranting obstruction should always be the first alternative considered. Limiting excavations to that which can be backfilled during the same work shift or covering minor excavations are practical examples of how obstructions, commonly encountered during construction, can be eliminated. In some cases, a detour may be the most practical solution, especially on projects that would require large quantities of construction barrier.

When construction barrier is not warranted, other traffic control devices such as cones, drums and breakaway barricades are still warranted. The New Jersey Turnpike and Garden State Parkway each require different devices. Refer to the Sample Plans for examples for each roadway.

There may be situations where there is not a clear choice as to whether or not a construction barrier is warranted or where site conditions or construction operations will exclude the use of a construction barrier even though one is warranted. The Engineer should constantly be on the lookout for situations where the site conditions and/or the operational characteristics of the road such as adverse geometrics, high operating speed and high traffic volume, will make the use of construction barrier appropriate even though not specifically required by the warrants shown in Subsection 9.8.2. Such cases should be evaluated on an individual basis and, in the final analysis, must usually be resolved by engineering judgment. In such cases, adequate documentation should be included in the job file so that whatever action is taken, it cannot be misconstrued as being arbitrary.

9.8.2 Warrants

The following guidelines are to be used to establish warrants for using Precast Concrete Construction Barrier when developing Traffic Control Plans. Three factors must be considered in determining if an obstruction warrants a construction barrier:

1. The physical characteristics of the obstruction.
2. The distance from the traveled way to the obstruction.
3. How long the obstruction will exist.

For an obstruction to warrant a construction barrier, all three of these criteria must indicate that a barrier is needed.

Physical Characteristics: A warranting obstruction is defined as a non-traversable roadside or a fixed object that is located within the clear zone and whose physical characteristics are such that injuries resulting from an impact with the obstruction would probably be more severe than injuries resulting from an impact with construction barrier.

Also, other examples of using construction barrier to protect patron vehicles from warranting obstructions are:

1. To protect traffic from entering work areas such as excavations.
2. To protect construction such as falsework for bridges and other exposed objects.
3. To separate two-lane, two-way traffic on one roadway of a normally divided roadway. Whenever two-way traffic is to be maintained on one side of a normally divided highway, opposing traffic shall be separated as follows and such separation shall be shown on the Traffic Control Plan.

   Where the two-lane, two-way, one-side arrangement is used, the Traffic Control Plans shall include the above provisions for the separation of opposing traffic except:

   a. Transition Zones - Positive Barrier (Pre-cast Concrete Construction Barrier or approved alternate), with a buffer area equal to the maximum deflection limit of the proposed barrier.

   b. Between Transitions - Positive Barrier, as described in A above or by delineation devices, such as drums, cones or vertical panels, as deemed appropriate by the appropriate Operations Department.

   c. Striping and complimentary signing shall be used in conjunction with A and B above.

Duration of Existence: A construction barrier is warranted if an obstruction will remain within the clear zone for more than one work shift.

9.8.3 Applications

Precast Concrete Construction Barrier, Alternates A and B are the only types approved for use on construction projects.

Construction Barrier Type 4, Alternate A should only be used at those locations where an allowable movement of the barrier, when hit, of 11 to 42 inches is acceptable. When the allowable deflection is less than 11 inches,

Alternate B shall be used. The type to be used at specific locations should be indicated on the Traffic Control Plans.

An alternate design to the Construction Barrier, Alternate A has been developed which may be substituted. This alternate Type 4 design, designated as Alternate B, Joint Class D has the same features as Alternate A, but has pockets to receive 1-inch diameter anchor bolts to meet the requirements for the Alternate A Construction Barrier. Refer to the Standard Drawings.

When Construction Barrier is specified, the Joint Class and limits for the barrier should be indicated on the Traffic Control Plans. Joint Class A should be specified where an allowable movement of over 16 to 42 inches is acceptable. Joint Class B should be specified where an allowable movement of over 11 to 16 inches is acceptable. Joint Class C should be specified where a maximum allowable movement of 11 inches is acceptable. ***The applicable joint class of Precast Concrete Construction Barrier shall be provided when the construction barrier is to be used as bridge parapet based on the width of the shelf provided for the allowable movement of the joint class.***

The following chart summarizes the respective joint treatments:

Joint Class	Use	Joint Treatment
A	Allowable movement over 16 to 42 inches	Connection Key only
B	Allowable movement over 11 to 16 inches	Connection Key and grout in every joint
C	Maximum allowable movement of 11 inches	Connection Key and grout in every joint and pin every other unit. In units to be anchored, pins should be required in every recess.
D	No allowable movement (i.e. bridge parapet)	Connection Key and grout in every joint and bolt every anchor pocket hole in every unit.

Pinning Alternate B to a bridge deck that is High Performance Concrete (HPC) or has a Latex Modified Concrete (LMC) overlay undermines the effectiveness of the HPC or LMC. In addition, the extra costs associated with placement of HPC or LMC make it especially undesirable to lessen its effectiveness by drilling holes through it. The Engineer is advised to investigate alternatives in order to eliminate the need for pinned barrier on bridge decks, when possible, so as not to compromise the benefits of the HPC or LMC overlay.

Precast Concrete Construction Barrier shall not be installed on side slopes steeper than 10H:1V. The approach end shall either be flared at 15:1 on the New Jersey Turnpike and 20:1 on the Garden State Parkway beyond the clear distance or, when terminated within the clear zone, the approach end of the barrier shall be shielded with an appropriate attenuator system.

The approach length of need (L.O.N.) is the minimum length of construction barrier required in front of the warranting obstruction to shield the hazard effectively. See Exhibit 9-1 for instructions on how to determine the L.O.N. of a Precast Concrete Construction Barrier.

EXHIBIT 9 - 1
LENGTH OF NEED OF PRECAST CONCRETE CONSTRUCTION BARRIER

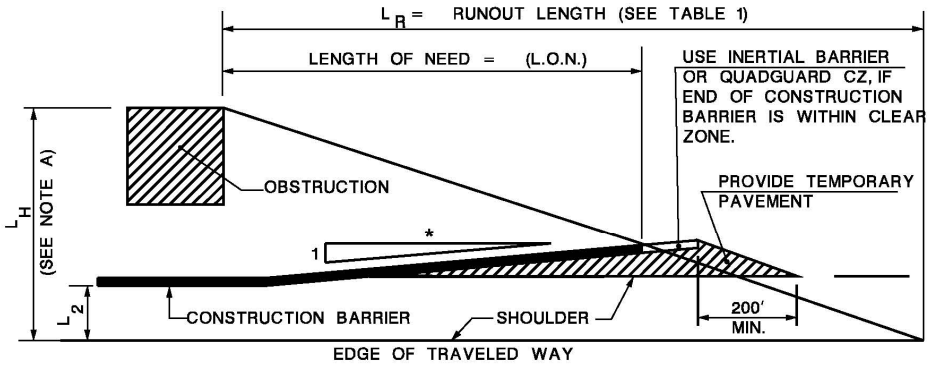


TABLE - 1				
	TRAFFIC VOLUME (A.D.T.)			
	OVER 6,000	2,000-6,000	800-2,000	UNDER 800
DESIGN SPEED (M.P.H.)	L_R	L_R	L_R	L_R
70	480	440	400	360
60	400	360	330	300
50	320	290	260	240
40	240	220	200	180
30	170	160	140	130

NOTE A: If obstruction extends behond Clear Zone, make L_H equal to Clear Zone, except if obstruction is a Critical Slope, see Exhibit 1B-44.

NOTE B: If Roadway is curved, draw layout to scale and obtain L.O.N. directly by scaling from drawing.

NOTE C: If barrier end is parallel to Roadway (no flare), then change "1/15" or "1/20" in formula to "0".

TURNPIKE (15:1)

EXAMPLE

$$L.O.N. = \frac{L_H - L_2}{\frac{1}{15} + \frac{L_H}{L_R}}$$

$L_2 = 15'$
$L_H = 25'$
$L_R = 480'$

$$L.O.N. = \frac{25 - 15}{\frac{1}{15} + \frac{25}{480}}$$

DESIGN SPEED = 70 mph
ADT = 26, 000

L.O.N. = 84.2'

SOURCE: AASHTO "ROADWAY DESIGN GUIDE" 2006

9.9 MOVABLE CONSTRUCTION BARRIER

9.9.1 Warrants

The following guidelines are to be used to establish the warrants for using Moveable Precast Concrete Construction Barrier to achieve an efficient and

effective Traffic Control Plan. Moveable barrier will provide additional traffic capacity lanes for accommodation of both AM and PM peak traffic, a safe and expeditious means of expanding the Contractor's work area (all work is done using positive separation), or the opportunity to stage projects in a more efficient method.

Moveable barrier should be a type that can be quickly moved laterally from 4 feet to 18 feet in one continuous operation. The daytime movement of moveable barrier can only be accomplished by means of a traffic slowdown. Therefore, the time required to relocate moveable barrier could preclude its use. The decision to use a moveable barrier system shall be approved by the appropriate Operations Department with capacity, safety and economics as the guidelines and should include the following considerations:

1. Additional traffic lane capacity can be gained during peak hour traffic periods.

2. Additional contractor working area can be gained during off peak hours and substantially reduce construction time.

3. Construction time can be shortened either through staging or increased productivity by the contractor.

4. Timing required to set up staging can be kept to a minimum.

5. Construction sites with limited work zones in urban or restricted areas where frequent day or nighttime lane closures will be required.

6. Their use will provide a greater degree of safety for motorists.

7. Projects which are located in non-attainment areas and have Clean Air Issues require a reduction in emissions.

9.9.2 Applications

When developing the Traffic Control Plan, the use of moveable barrier systems should be limited to projects where a greater benefit can be attained than if standard methods and equipment were used. Listed below are types of projects where it would be a viable option for use.

1. Widening or reconstruction projects on highways or expressways with high peak hour traffic volumes (i.e. 50,000 AADT and greater for four lane facilities and 90,000 AADT and greater for 6 lane facilities).

2. Projects where a reversible traffic lane would be beneficial during peak traffic durations and which would allow for better staging.

3. Median and shoulder reconstruction projects. Examples include shoulder/median improvements or widenings, such as a new permanent concrete barrier being installed. Moveable barrier is especially beneficial

when the size of the work zone is either very restricted or if repeated lane closures are anticipated.

4. For resurfacing projects by closing one side of a divided highway and creating opposing traffic lanes on the open side of the road, a contractor can resurface one side of the roadway at night without interference from traffic.

5. For Reconstruction of parallel structures where the design of a reversible lane to increase the capacity of one structure while closing down the other.

6. Alternate routes do not have excess capacity for suitable detour.

7. Alternate routes do not exist.

9.9.3 Safety and Cost Considerations

In construction projects, moveable barrier generally is used to open traffic lanes during peak traffic periods and close the lanes during off peak periods to allow improved access to the work zone. In this application, the moveable barrier has the unique ability to provide continuous positive protection before, during and after the opening and closing of traffic lanes. Once these barriers are on the road, it takes significantly less time to shift barrier than it does by using traditional methods. Moveable Barrier allows greater work zone access for a contractor and increases productivity. A determination should be made by the Engineer that this feature and resulting increased worker safety makes the use of a moveable barrier system a viable alternative to conventional traffic control devices. Its use should be clearly described in the Traffic Control Plan.

When considering this product the Engineer should also prepare a cost comparison of the moveable barrier and the next best alternative. The following items should be considered:

1. Cost of the moveable barrier. The Engineer should work with the supplier to determine operational costs and a lease price to contractors.

2. The next best alternative and its cost.

3. The savings in time for the project's schedule should also be considered with the overall savings.

4. Consideration for congestion and clean air issues where a reduction in emissions is required.

Use of moveable barrier should take into consideration access to interchanges, service areas, maintenance facilities, emergency access points, etc., where access must be maintained during construction.

When using moveable barrier, consideration for additional wide load signing on the Traffic Control Plans may be appropriate. If the barrier is used to reverse traffic flow and there is a single lane in one direction, it shall not be less than 11 feet.

Moveable barrier shall only be used on tangent sections and flat curves where an angle of impact of not more than seven degrees exists and where an allowable movement of the barrier, when hit, of 1 ½ feet is acceptable. Moveable barrier can be used on the following sharp curves where an allowable movement of the barrier, when hit, of 5 feet is acceptable:

Number of Lanes	5 ft Deflection where Radius is less than
1	500 feet
2	900 feet
3	1,300 feet

Approved attenuators, as identified on the Authority's website, must be used with moveable barrier to shield the approach ends of the barrier. Where possible, the barriers may be tucked behind conventional concrete barrier curb.

9.10 NIGHTTIME CONSTRUCTION

In keeping with the Authority's policy of delivering a safe, reliable and affordable transportation system and to alleviate traffic congestion and improve air quality, it is proposed that any activity that requires the temporary closing of traffic lanes which results in a sufficient degradation of the highway level of service, should be performed at night provided that the requirements of the Authority's Traffic Control Manuals are met. Excluded will be emergency operations such as locations where safety conditions preclude nighttime work, locations where existing municipal ordinances have been enacted that prohibit nighttime work, or locations where the traffic volumes are such that the work activity can be accomplished during the day without significant negative impacts.

It is the intent of the Authority to perform construction activities at night that would otherwise cause unacceptable negative impact on traffic flow. It is recognized that there are certain influencing factors that must be reviewed when considering whether or not to perform nighttime work.

The decision to perform nighttime work will be determined during the scoping process, but the final approval for nighttime construction should be made by the Authority's project manager, with the approval of the appropriate Operations Department. The following guidelines are to be used for establishing the warrants for nighttime work outside of the Authority's right of way.

1. The conditions listed below must be met before nighttime work can be performed:
   a. Compliance with local noise restriction ordinances.

b. The Authority has obtained local government approval for nighttime work within the project limits. (Inform local government of what type of work will be taking place.)
c. Work zone safety must not be compromised by nighttime construction activities.
d. The quality of construction work must not be compromised by nighttime work.

2. Some factors that may eliminate the need for nighttime work:
   a. A shoulder which may be used in place of the lane to be closed.
   b. A viable detour is available.
   c. Operations Department staff and the Traffic Impact Report indicate that a lane closure during the day would not cause a significant impact.

3. Projects that may require both day and nighttime construction operations are as follows:
   a. Projects where the location has specific seasonal requirements (such as shore routes during the summer, major shopping centers at the Holiday Season, sports facilities, etc.).
   b. Projects where the work required has specific temperature or environmental constraints.
   c. Projects with accelerated construction schedules.

9.11 CONSTRUCTION DETAILS

Construction details should be provided for any traffic control device not adequately covered by the Standard Drawings.

9.11.1 Temporary Attenuators

Temporary attenuators in construction zones shall not be placed on side slopes steeper than 5%, or on islands, curbs, platforms, etc. greater than 4 inches in height. The Engineer should refer to Subsection 9.17 for information on the selection and design of the Inertial Barrier Systems. Alternate systems currently approved by the Authority are provided on the Authority's website. The Engineer must provide design specific information such as the required number of bays or modules for each location. For Inertial Barrier systems, a layout of the modules, including the weight of each module shall be included as a construction detail in the contract plans.

9.11.2 Signs

9.11.2.1 General

1. Any construction sign not depicted on the Standard Drawings shall be shown in detail.
2. All signs should be sized relative to the posted speed limit (i.e. use 4 by 3 feet for posted speeds greater than 40 mph).
3. Determine if specific site conditions require special supplemental signing. The use of variable message boards should be considered and approved by the Authority's appropriate Operations Department.

9.11.2.2 Tables for Construction Signs

In order to estimate the required quantity of signs in square feet, the Engineer should prepare a summary of signs for the project. This summary of construction signs shall be shown on a table, and included on the first sheet of the Traffic Control Plans. An example of a completed table listing the sign designation, quantity and area in square feet is shown in the Sample Plans.

9.11.3 Guide Rail

Guide rail in construction zones shall not be installed on side slopes steeper than 10H:1V.

9.12 UTILITIES

Utility relocations that affect staging or traffic control should be clearly identified on the Traffic Control Plans. This information should include both temporary and permanent relocation work. Notes pertinent to the relocations should be provided on the applicable staging plan(s) and/or traffic control plan(s). In addition, the Engineer should review the need for general utility notes to be added.

9.13 QUANTITIES

Quantities should be estimated based upon actual requirements shown on the plans.

For quantity purposes, the number of units or linear feet of traffic control devices and signs should be the maximum quantity required to be in use at any one time. Construction signs should be tabulated by sign designation and quantity, refer to Subsection 9.11.2. Signs indicating speed limits or speed reductions shall be included.

Temporary pavement to be used for traffic control shall be measured and paid for under the various pavement pay items in the Proposal. Quantities for the removal of temporary pavement must also be included.

9.14 INSTALLATION AND REMOVAL SEQUENCE FOR WORK ZONE TRAFFIC CONTROL

The manner in which traffic control schemes are installed and removed may affect safety and traffic flow. The following is a suggested guideline describing the proper installation and removal sequence for work zone traffic control schemes:

1. Required advance warning signs should be installed first so that protection is provided when channelizing devices are installed near the work area. If work zone signing is necessary for both directions of travel, sign installation should begin with the advance warning sign located furthermost in advance of the work area and on the side of the roadway opposite the work area. Sign installation should proceed down the roadway toward the work area. After the necessary signs are erected on the side of the roadway opposite the work area, sign

installation may begin for the other direction of travel, beginning with the sign furthermost from the work area. In the process of installing the work zone signing, existing signs with conflicting messages shall be completely covered, removed or modified.

2. If the work area is such that flagging operations are necessary, the flaggers may begin flagging operations after the advance warning signs are in place. Otherwise, the installation of channelizing devices at the work area can begin after the placement of the advance warning signs. These devices should also be installed in the direction of travel starting with the device furthermost in advance of the work area.

3. A shadow vehicle with a truck-mounted attenuator should be placed between approaching traffic and the workers who are installing channelizing devices around the work area. After the channelizing devices are installed, the vehicle may be removed or moved inside the work area and the work may begin.

4. After work is completed and the work zone restored to normal operations, the work zone traffic control scheme may be dismantled. The removal of the traffic control scheme should be carried out in reverse order from the installation procedure. The channelizing devices which surround the work site should be removed first, followed by flaggers that may have been used. The work area signing may then be removed and normal traffic patterns restored.

9.15 MAINTENANCE AND PROTECTION OF TRAFFIC PLAN SUBMISSION REQUIREMENTS

9.15.1 Phase "A" Submission

Conceptual Construction Sequence Plans should be prepared at either 1"=100' or 1"=200' scale to show the overall approach to constructing the project. The plans should show existing and proposed roadways with a brief explanation of the construction sequence, including any detours.

9.15.2 Phase "B" Submission

Investigate project site specific conditions and Prepare Preliminary Maintenance and Protection of Traffic Plans:

1. Visit project site and note locations of the following:
   a. Horizontal and vertical sight distance restrictions due to existing roadway conditions (i.e. roadside vegetation, adjacent property usage, overpass bridge structures, sign structures, barrier curb, guide rail and/or horizontal and vertical geometry).

   b. Expected pedestrian activity, crosswalks, parks, schools, universities, bus routes, school bus routes, bus stops, emergency vehicle access routes, churches, stadiums, and/or shopping and industrial areas. When a park is located within the project limits, obtain a calendar of events and the name, address and phone number of the individual to contact for coordination of construction staging. Also obtain a

calendar of major traffic generating events from the Authority's appropriate Operations Department where applicable.

c. Existing emergency facilities for fire, rescue and/or police; where traffic signals exist, note if they are equipped with an optically controlled emergency vehicle detection system or a pre-empted system to provide for clearance of adjacent railroad crossings.

d. Look for alternate routes which can be used as detour routes or congestion relief.

2. Review of Existing Information
   a. Review as-built plans and/or collect field data necessary to determine the horizontal and vertical sight distances of the existing roadway throughout the project limits including 1,000 feet beyond each terminus.

   b. For roadways outside of the Authority's right of way, obtain existing peak-hour traffic counts from the agencies with jurisdiction, with vehicle classification and 24-hour ATR traffic counts. Use this data to support decisions regarding minimum lanes to be maintained, detour requirements and work hours.

   c. Review existing crash information to determine if any specific type of vehicle crashes may affect the proposed staging plans.

   d. Determine if the traffic flow within the project area has any seasonal characteristics such as shore route, Holiday shopping route, etc.

   e. Determine the agencies which have jurisdiction over the project area and potential detour routes.

3. Prepare Roadway plans in accordance with Section 3 (Submission Requirements) of the Procedures Manual. Note features that will affect traffic control such as number of lanes and lane widths, existing shoulder widths and pavement thickness, merge and weave requirements for ramps, lateral clearance restrictions, vertical and horizontal clearances at structures, structural widths (i.e., parapet to parapet, abutment to abutment, stringer spacing, etc.) and the location of major utilities, including the effect on their future maintenance.

4. Prepare Maintenance and Protection of Traffic Plans to show the overall approach to the required stages of construction of the project considering site specific conditions and work to be accomplished. Identify issues, constraints and time frames associated with the various stages to be studied in greater detail during Phase "C". If a project requires the relocation of utilities, the staging plans shall take into account any staging requirements necessary for such relocations.

5. Prepare a Traffic Impact Report as discussed in Subsection 9.4.

6. Contact and coordinate with appropriate State, County and Local Authorities (i.e. New Jersey Department of Transportation, South Jersey Transportation Authority, etc.) to obtain the required permits needed to enter upon lands under their jurisdiction. This coordination effort should include, but not be limited to:
   a. Permits required and fees.
   b. Authority's Traffic Control Plan Standards.
   c. Insurance requirements.
   d. Materials specifications.
   e. Agreements between Agencies to perform certain types of work.

9.15.3 Phase "C" Submission

Prepare Final Maintenance and Protection of Traffic Plans:

1. Perform field visits and collect additional field data as necessary during the development of the Final Traffic Control Plans and Staging Plans.

2. The first two sheets of the Maintenance and Protection of Traffic Plans should be as shown on the Sample Plans, modified to address project site specific conditions. These sheets should contain General Notes, a Standard Legend of typical traffic control devices and a table showing recommended spacing of the channeling devices if project specific traffic control plans have been added to the contract plans.

3. Review the Standard Drawings, select details applicable to the project and modify to reflect the specific site constraints and construction procedures required to construct the project.

4. Review the Legend and modify to include other project specific symbols as necessary for traffic control.

5. Review the need for travel lane restrictions.

6. Review hours of operations or lane restrictions determined in the Preliminary Submission. Consideration should be given to the location of the project, calendar of events, etc.

7. Review the Traffic Control Detail General Notes and select the notes applicable to the project. Additional project specific notes should be added as necessary. The notes should include but not be limited to:
   a. specific restrictions placed on travel lanes,
   b. durations of closures,
   c. hours when work may be performed (include holidays and weekend hours),
   d. number of lanes of unobstructed traffic to be maintained in each direction,
   e. staging of traffic signals,
   f. temporary drainage,
   g. allowable minimum widths of traveled way and if detour routes have to be established for over width vehicles,
   h. number of lanes to be open to traffic,

i. diversionary routes with any restrictions,
j. traffic lanes or patterns to be maintained during construction for local roads affected by construction,
k. contractor's access and staging areas,
l. provisions for maintaining access to driveways,
m. signing for temporary access driveways to commercial developments.

8. The Sample Plans shall be modified to include other project specific information necessary to adequately address traffic control needs as follows:
   a. Where required for clarification, sectional views showing the placement of traffic control devices, such as construction barrier, adjacent to the traveled way and the work site shall be provided.
   b. When ramps or jughandles are to be reconstructed, consideration should be given to the effect that the work will have on traffic patterns or flow. Traffic Timing Plans for traffic signals may have to be altered. It is desirable that local government or the New Jersey Department of Transportation assume the maintenance of these facilities at the completion of construction.
   c. The need for a detour route should be considered if a ramp or jughandle is to be closed for construction. Also, where work is to be performed on a ramp or jughandle whose width is less than 14 feet, that ramp or jughandle should be closed while the work is being done or if the ramp cannot be closed, a temporary ramp widening may be required. When reconstructing a shoulder, consider the use of a temporary traffic shift to provide a buffer between the work zone and the traveling public.

9. Following the first two (2) sheets, prepare additional Maintenance and Protection of Traffic Plans to show plan views of project specific work sites when these locations need to be represented or where design features of traffic control devices or temporary pavement markings need to be indicated. Issues to address on the plans should include but are not limited to those listed in Item 7 above. These plans should contain notes pertaining to the various stages of construction that thoroughly describe each phase of construction in the sequence to be performed. In addition, utility relocations that affect the staging of construction should be clearly identified within the sequence of work.

10. When temporary pavement areas are required, a typical section should be provided.

11. Prepare and include in the Maintenance and Protection of Traffic Plans the method of removal of surface water runoff during each stage of construction.

12. Review the construction staging to determine any seasonal constraints due to weather (i.e. snow removal etc).

13. Determine the constructability of the construction staging by reviewing the sequencing of work and methods of construction.

14. When staging the successive passes of resurfacing, consideration should be given to the location of the longitudinal pavement edge. Avoid placement of these edges within the wheel path.

15. Determine if underground work (i.e. new storm drains, pipelines, gas, electric, etc.) is sequenced to coincide with or enhance construction phasing, and that this work will meet traffic control constraints for lanes, etc. (i.e. check limits on applying a back slope in trenches when calculating lateral clearances. Also check if sheeting or a trench box will be required. Standard segment lengths of pipe should also be considered.)

16. If required, prepare temporary traffic signal plans, details and traffic signal timing plans associated with the staged installation of new signals.

17. Prepare construction details for any traffic control device not adequately covered in the Standard Drawings such as the following:
    a. Details for all temporary barriers and crash cushions to be utilized on the project, refer to Subsection 9.11.
    b. Construction signs not depicted in the Standard Drawings.

18. Prepare and include in the Maintenance and Protection of Traffic Plans, a tabulation of the channelization devices needed for the project.

19. Obtain Traffic and Parking restriction ordinances approved by municipalities.

20. Establish a maximum length of lane closure, length of alternating traffic and maximum number of intersections affected.

9.16 QUALITY CONTROL CHECKLIST FOR ENGINEERS

Engineers shall refer to checklist, posted on the Authority's website, throughout the development of the Maintenance and Protection of Traffic Plans and include with the Phase "C" Submission. An explanation is required for any "No's" checked.

9.17 TEMPORARY ATTENUATOR SELECTION AND DESIGN GUIDELINES

9.17.1 General

Once it has been determined that an attenuator is to be used to prevent errant vehicles from impacting a fixed object, a choice must be made as to which attenuator is best for the particular location under consideration. The attenuators presently recommended for temporary installations on Authority projects are inertial barrier and any attenuators on the Authority's website approved for temporary use. See Section 3 (Guide Rail / Median Barrier / Attenuator Design) of this Manual for the design of permanent attenuators.

Several factors must be evaluated when determining which of the recommended attenuators should be used. The number and type of factors to be evaluated precludes the development of a simple, systematic selection procedure. The factors which normally should be considered are briefly discussed below. In many cases, evaluation of the first few items will establish the type of attenuator to be used. When designing an attenuator, take the time to review the design instructions and product limitations in the manufacturer's design manual thoroughly before performing the necessary work. The Engineer shall review the manufacturer's design instructions and product limitations before specifying this product.

9.17.2 Dimensions of the Obstruction

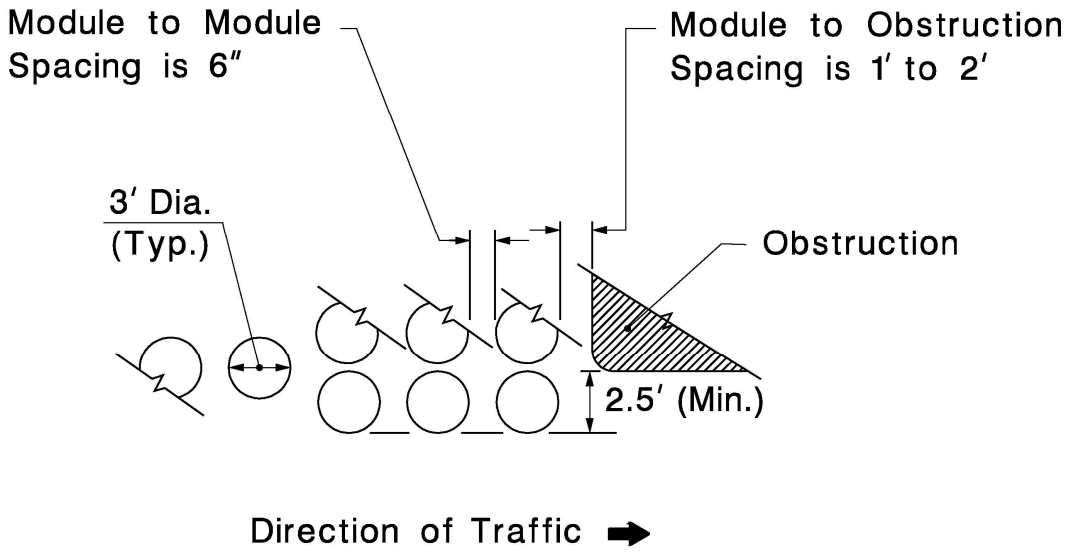
Inertial barriers can be designed to prevent errant vehicles from impacting a fixed object of practically any width.

9.17.3 Space Requirement

Area occupied by the attenuator:

To meet the requirement of Exhibit 9 - 2, inertial barriers will have a minimum width of approximately 6.5 feet (two barrels each at 3 feet wide plus a 6-inch space between them).

EXHIBIT 9 - 2
LAYOUT FOR LAST THREE MODULE ROWS IN AN INERTIAL BARRIER



NOTE:

A minimum of two modules must be provided in the last three rows.

9.17.4 Geometrics of the Site

The vertical and horizontal alignment, especially curvature of the road and sight distance, are important factors to be considered. Adverse geometrics could contribute to a higher than normal frequency of impacts.

9.17.5 Physical Conditions of the Site

See Section 3 (Guide Rail / Median Barrier / Attenuator Design) of this Manual.

9.17.6 Redirection Characteristics

Since sandfilled plastic barrels have no redirection capabilities, it is important that the recommended placement details shown in Exhibit 9-2 be adhered to so as to minimize the danger of a vehicle penetrating the barrier from the side and hitting the obstructions.

9.17.7 Allowable Deceleration Force

See Section 3 (Guide Rail / Median Barrier / Attenuator Design) of this Manual.

9.17.8 Anchorage Requirements

Some approved systems require an anchorage which is capable of restraining the crash cushion during an impact. The manufacturer's standard designs of these crash cushions include the necessary anchorage. Refer to the Authority's website for currently approved temporary attenuators.

9.17.9 Flying Debris Characteristics

Impact with an inertial barrier will produce some flying debris, but not enough to deter their use.

9.17.10 Initial Cost

Compare initial costs of approved attenuators.

9.17.11 Maintenance

Inertial barriers are particularly susceptible to damage during minor impacts. At locations where nuisance hits may be common or there is a high probability of crashes, attenuators with redirection capabilities should be considered as a means of reducing maintenance requirements.

9.17.12 Design Procedure

9.17.12.1 Inertial Barrier

The design of an inertial barrier is based on the law of conservation of momentum. It can be shown that:

Equation 1

$$\mathbf{V_F = W\ (V_O\ /\ (W+W_S))}$$

$\mathbf{V_F}$= velocity of vehicle after impact with M_s, in fps
$\mathbf{V_O}$ = velocity of vehicle prior to impact with M_s, in fps
W = weight of vehicle, in lbs.
$\mathbf{W_S}$ =weight of sand actually impacted by a 6 foot wide vehicle, in lbs.

This equation is used to calculate the velocity of a vehicle as it penetrates the inertial barrier. When a vehicle has been slowed to approximately 10 mph or less (14.7 fps) per Equation 1, it will actually have been stopped because of deceleration forces that have been neglected in Equation 1.

Slowing of the vehicle must take place gradually so that the deceleration force is 6G desirable, 8G maximum. The deceleration force is calculated using Equation 2. Note that velocity is in feet per second (fps).

Equation 2

$$\mathbf{G = (V_O^2 - V_F^2) / 2Dg}$$

G = deceleration force in G's
$\mathbf{V_O}$ = velocity of vehicle prior to impact, in fps
$\mathbf{V_F}$ = velocity of vehicle after impact with one row of modules, in fps
D =distance traveled in decelerating from $\mathbf{V_O}$ to $\mathbf{V_F}$ (Usually **D** = width of a module = 3 ft.)
g =32.2 ft/s^2

All temporary impact attenuators shall be designed for the posted regulatory speed limit prior to the start of the construction zone plus an additional 5 MPH.

The standard weights of modules used are 200 lbs., 400 lbs., 700 lbs., 1,400 lbs., and 2,100 lbs. However, the use of 2,100 lbs. module is not recommended unless site conditions are restricted and the use of 1,400 lbs. modules would not stop the vehicle from striking the obstruction.

A minimum of 2 modules are required in the last 3 rows of the barrier array to meet the 2.5 foot criteria shown in Exhibit 9 - 2. An additional last row of 1,400 lbs. modules is provided after required reduction in speed is obtained. When a wide obstruction is being shielded, the modules may be spaced up to 3 feet apart. However, this spacing must be accounted for in the design. $\mathbf{W_S}$ in Equation 1 is the weight of sand impacted by a 6-foot wide vehicle. Therefore, if 1,400 lbs. modules (3-foot diameter) were spaced 2 feet apart, $\mathbf{W_S}$ would equal 1,867 lbs.

Exhibit 9 - 3, Exhibit 9 - 4, Exhibit 9 - 5, and Exhibit 9 - 6 illustrate typical sand barrel configurations for narrow barrier arrays.

In the following two examples, first check the sand barrel configuration shown in Exhibit 9 - 5 for an 1,800 lb. vehicle and

then make the same check for a 4,500 lb. vehicle. Assume a design speed of 60 mph (88 fps).

Example of Inertial Barrier Design for 1,800 lb. Vehicle:

ROW	W_S	V_O	V_F*	G*
1	200	88	79.2	7.6**
2	200	79.2	71.3	6.2
3	200	71.3	64.2	5.0
4	400	64.2	52.5	7.1
5	700	52.5	37.8	6.9
6	700	37.8	27.2	3.6
7	1400	27.2	15.3	2.6
8	2800	15.3	6.0	1.0
9	2800	--	--	--
10	2800	--	--	--

* V_F and G are calculated using Equations 1 & 2.

** It is desirable to limit G for each row to a maximum of 6. However, since 200 lbs. is the lightest module recommended for use, the 7.6 cannot be decreased.

Example of Inertial Barrier Design for 4,500 lb. Vehicle:

ROW	W_s	V_o	V_F*	G*
1	200	88	84.3	3.3
2	200	84.3	80.7	3.1
3	200	80.7	77.2	2.9
4	400	77.2	70.9	4.8
5	700	70.9	61.4	6.5
6	700	61.4	53.1	4.9
7	1400	53.1	40.5	6.1
8	2800	40.5	25.0	5.3
9	2800	25.0	15.4	2.0
10	2800	--	--	--

ALL ARRAYS SHALL BE DESIGNED TO ACCOMMODATE BOTH 1800 LB AND 4500 LB VEHICLES.

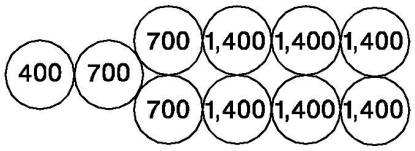
Since the assumed configuration (shown in Exhibit 9 - 5) meets all the requirements specified in the previous examples, no changes are necessary.

Manufacturers of inertial barriers have developed designs for various obstructions. Most of these designs are based on a maximum deceleration force of 6G's. However, the space required for a 6G design will not always be available, especially in gore areas, in which case, a design for higher deceleration forces (8G's maximum) may be used.

A layout of the modules including the weight of each module must be included as a construction detail in the contract plans.

Sand barrel layouts for wide obstructions are to be designed in accordance with the manufacture's instructions.

EXHIBIT 9 - 3
TYPICAL SAND BARREL CONFIGURATION – 40 MPH DESIGN



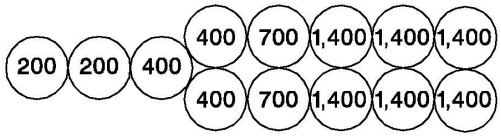
40 MPH DESIGN - 4,500# VEHICLE

ROW	W_S (LB)	V_o	V_f	G
1	400	58.7	53.9	2.8
2	700	53.9	46.6	3.8
3	1,400	46.6	35.5	4.7
4	2,800	35.5	21.9	4.0
5	2,800	21.9	13.5	1.5
6	2,800	-	-	-

40 MPH DESIGN - 1,800# VEHICLE

ROW	W_S (LB)	V_o	V_f	G
1	400	58.7	48.0	5.9
2	700	48.0	34.6	5.7
3	1,400	34.6	19.5	4.2
4	2,800	19.5	7.6	1.7
5	2,800	-	-	-
6	2,800	-	-	-

EXHIBIT 9 - 4
TYPICAL SAND BARREL CONFIGURATION – 50 MPH DESIGN



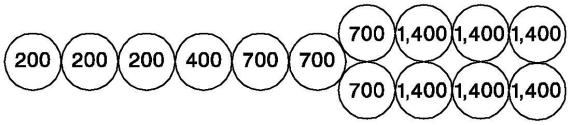
50 MPH DESIGN - 4,500# VEHICLE

ROW	W_S (LB)	V_O	V_f	G
1	200	73.3	70.2	2.3
2	200	70.2	67.2	2.1
3	400	67.2	61.7	3.7
4	800	61.7	52.4	5.5
5	1,400	52.4	40.0	5.9
6	2,800	40.0	24.7	5.1
7	2,800	24.7	15.2	2.0
8	2,800	-	-	-

50 MPH DESIGN - 1,800# VEHICLE

ROW	W_S (LB)	V_O	V_f	G
1	200	73.3	66.0	5.3
2	200	66.0	59.4	4.3
3	400	59.4	48.6	6.0
4	800	48.6	33.6	6.4
5	1,400	33.6	18.9	4.0
6	2,800	18.9	7.4	1.6
7	2,800	-	-	-
8	2,800	-	-	-

EXHIBIT 9 - 5
TYPICAL SAND BARREL CONFIGURATION – 60 MPH DESIGN



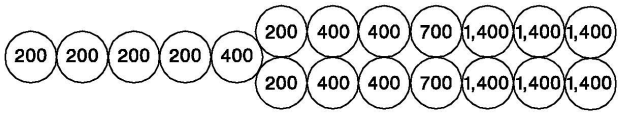
60 MPH DESIGN - 4,500# VEHICLE

ROW	W_s (LB)	V_o	V_f	G
1	200	88.0	84.3	3.3
2	200	84.3	80.7	3.1
3	200	80.7	77.2	2.9
4	400	77.2	70.9	4.8
5	700	70.9	61.4	6.5
6	700	61.4	53.1	4.9
7	1,400	53.1	40.5	6.1
8	2,800	40.5	25.0	5.3
9	2,800	25.0	15.4	2.0
10	2,800	-	-	-

60 MPH DESIGN - 1,800# VEHICLE

ROW	W_s (LB)	V_o	V_f	G
1	200	88.0	79.2	7.6
2	200	79.2	71.3	6.2
3	200	71.3	64.2	5.0
4	400	64.2	52.5	7.1
5	700	52.5	37.8	6.9
6	700	37.8	27.2	3.6
7	1,400	27.2	15.3	2.6
8	2,800	15.3	6.0	1.0
9	2,800	-	-	-
10	2,800	-	-	-

EXHIBIT 9 - 6
TYPICAL SAND BARREL CONFIGURATION – 70 MPH DESIGN



70 MPH DESIGN - 4,500# VEHICLE

ROW	W_S (LB)	V_o	V_f	G
1	200	102.7	98.4	4.5
2	200	98.4	94.2	4.2
3	200	94.2	90.2	3.8
4	200	90.2	86.4	3.5
5	400	86.4	79.2	6.0
6	400	79.2	72.7	5.1
7	800	72.7	61.7	7.7
8	800	61.7	52.5	5.5
9	1400	52.5	40.0	6.0
10	2800	40.0	24.6	5.1
11	2800	24.6	15.3	2.0
12	2800	-	-	-

70 MPH DESIGN - 1,800# VEHICLE

ROW	W_S (LB)	V_o	V_f	G
1	200	102.7	92.4	10.4
2	200	92.4	83.2	8.4
3	200	83.2	74.9	6.8
4	200	74.9	67.3	5.5
5	400	67.3	55.1	7.8
6	400	55.1	45.2	5.2
7	800	45.2	31.2	5.5
8	800	31.2	21.6	2.6
9	1400	21.6	12.2	1.7
10	2800	12.2	4.7	.6
11	2800	4.7	1.9	.1
12	2800	-	-	-